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NOTIFICATION OF ELECTION

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Applicant KIM, You, Kwang et al	

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[ ] in a notice effecting later election filed with the International Bureau on:

2. The election [X] was

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NOTIFICATION OF THE RECORDING OF A CHANGE

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From the INTERNATIONAL BUREAU

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1. The following indications appeared on record concerning:

[X] the applicant [X] the inventor [ ] the agent [ ] the common representative

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3. Further observations, if necessary:

4. A copy of this notification has been sent to:

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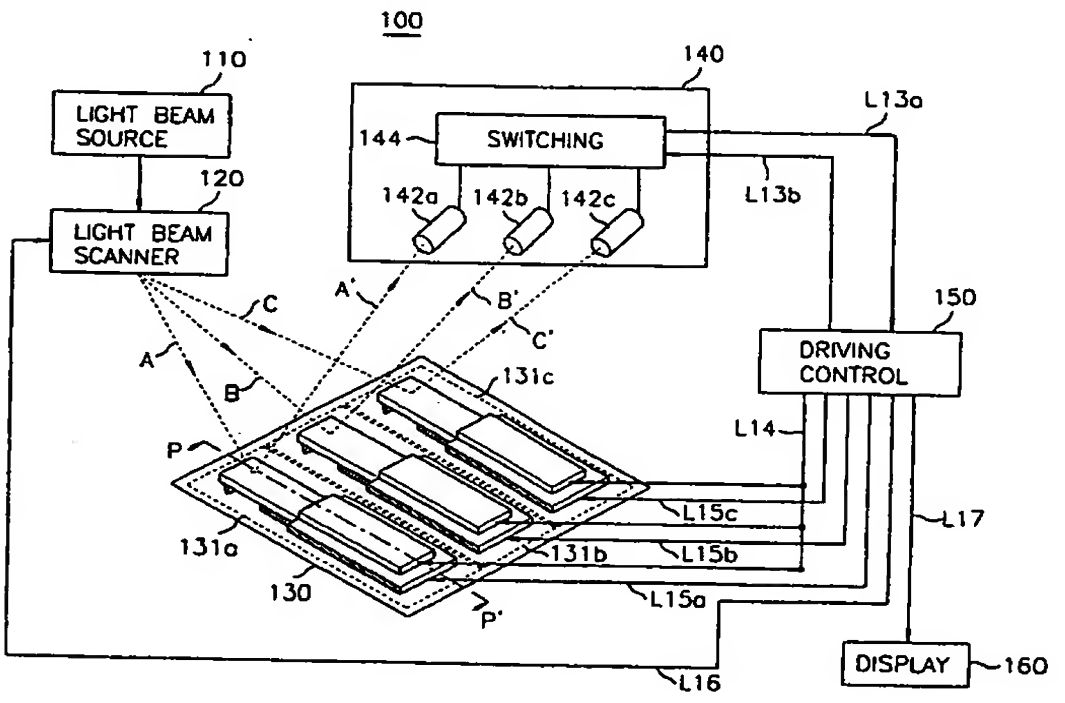

(57) Abstract: An atomic force microscope (AFM) capable of observing the topography of a sample surface at high speed with a high resolution under the atmospheric pressure and a driving method therefor is provided. The AFM comprises a light beam source unit, a light beam scanner, a scanning probe unit (or matrix), a light beam detection unit, a driving control unit and a display unit. The driving method comprises the steps of vibrating, responsive to a reference signal, a first actuator provided on each of scanning probes; detecting a deflection amount of a cantilever provided with a tip at its free end; and transmitting a servo signal to a second actuator based on the deflection amount of the cantilever.

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ATOMIC FORCE MICROSCOPE AND DRIVING METHOD THEREFOR

TECHNICAL FIELD OF THE INVENTION

The present invention generally relates to an atomic force microscope and a driving method therefor; and, more particularly, to an atomic force microscope equipped with plural scanning probes capable of observing the topography of a sample at high speed with a high resolution under the atmospheric pressure and to a driving method therefor.

BACKGROUND ART

A variety of techniques have been utilized to observe the topography of a surface, such as the surface of a semiconductor device. A scanning probe microscope such as an atomic force microscope (AFM) is a microscope capable of observing a surface with a high resolution in nanometer or sub-nanometer range without damaging the surface observed by scanning the surface using, as a feedback signal, a signal generated by the inter-atomic force between the surface observed and a tip provided on a scanning probe, while keeping a constant interval between the surface observed and the tip.

U.S. Pat. No. 5,338,932 entitled "METHOD AND APPARATUS FOR MEASURING THE TOPOGRAPHY OF A SEMICONDUCTOR DEVICE" issued to Theodore et al. discloses an apparatus and method for performing a combination of atomic force microscopy and scanning tunneling microscopy measurements to provide an accurate representation of a surface's topography and a material composition. A variable flexibility probe of the apparatus includes a reference element, a variable stiffness element, a support member, a conductive tip and a force element. A first end of the reference element and a first end of the variable stiffness element are attached to the support member so that the reference and the variable

stiffness element form two parallel cantilever arms that project from the support member.

The force element is attached to both the reference and the variable stiffness element. The force element applies a variable force to the variable stiffness element in order to vary the stiffness or spring-constant of the variable stiffness element. Although the variable flexibility probe can perform a combination of atomic force microscopy and scanning tunneling microscopy measurements, it would be difficult to downscale the dimension of the variable flexibility probe in order to construct a system employing a plurality of the variable flexibility probes, since the variable flexibility probe is made of two parallel cantilever arms separated from each other with a small gap and including the force element therebetween.

U.S. Pat. No. 5,468,959 entitled "SCANNING PROBE MICROSCOPE AND METHOD FOR MEASURING SURFACES BY USING THIS MICROSCOPE" issued to Tohda et al. discloses a scanning probe microscope of advanced functions combining atomic force microscopy and scanning tunneling microscopy equipped with an active cantilever and a method for observing surfaces by using this microscope. This microscope may be operated at the atmospheric pressure, however, it will be preferable to place this microscope in a super-high vacuum if a measurement for obtaining detailed information of a clean sample surface is required. While this microscope has an advantage capable of being operated under the atmospheric pressure, it would be difficult to downscale the dimension of a scanning probe employed in the microscope since the scanning probe has a large structure for varying a stiffness or spring-constant of the scanning probe as similar to the one by Theodore et al.

U.S. Pat. No. 5,723,775, entitled "ATOMIC FORCE MICROSCOPE UNDER HIGH SPEED FEEDBACK CONTROL" issued to Watanabe et al. discloses an atomic force microscope (AFM) capable of performing a high-speed feedback control achieved

by decreasing the mass of a cantilever including an axial driving actuator while eliminating drawbacks caused by the decrease in mass. The AFM scans the structure of a sample to be observed while keeping the constant interval between the surface of the sample and a tip provided on a scanning probe. However, an image representing the topography of the sample surface will be degraded when the tip is contaminated by impurities, e.g., dusts, drops of water and the like which may exist on the surface of the sample observed under the atmospheric pressure.

As described above, none of the aforementioned patents teach a system with plural scanning probes and a driving method therefor capable of observing the topography of a sample surface. When a system employing plural scanning probes is constructed by employing one of techniques described in the aforementioned patents, it will end up to be an expensive and bulky system. Therefore, it is desirable to provide a system, which is inexpensive and of a compact size, with plural scanning probes and a driving method therefor in order to observe the topography of a sample surface at high speed with a high resolution under the atmospheric pressure.

DISCLOSURE OF THE INVENTION

It is, therefore, an object of the present invention to provide an atomic force microscope capable of observing the topography of a sample at high speed with a high resolution under the atmospheric pressure and a driving method therefor.

In accordance with one aspect of the present invention, there is provided an atomic force microscope (AFM) capable of observing the topography of a sample surface at high speed with a high resolution under the atmospheric pressure, comprising: a plurality of scanning probes for measuring the sample surface, wherein each of the scanning probes includes

a cantilever having a tip and a first and a second actuator; means for detecting a light beam reflected from said each of the scanning probes to convert same into a first signal depending on a second signal; and means for driving the scanning probes by generating a third and a fourth signal and detecting information regarding the topography of the sample surface, wherein the first actuator performs a tapping operation in response to the third signal, the second actuator performs a positioning operation in response to the fourth signal and the frequency of the third signal is higher than that of the fourth signal.

In accordance with another aspect of the present invention, there is provided an atomic force microscope capable of observing the topography of a sample surface at high speed with a high resolution under the atmospheric pressure, comprising: a scanning probe matrix having N x M scanning probes thereon for measuring the sample surface, wherein each of the scanning probes includes a cantilever having a tip and a first and a second actuator, N and M being positive integers greater than 1, respectively; means for detecting a light beam reflected from said each of the scanning probes to convert same into an electrical signal; and means for driving the scanning probes by generating a reference and a servo signal and detecting information regarding the topography of the sample surface, wherein the first actuator performs a tapping operation in response to the reference signal, the second actuator performs a positioning operation in response to the servo signal and the frequency of the reference signal is higher than that of the servo signal.

In accordance with still another aspect of the present invention, there is provided a method for driving an atomic force microscope (AFM) with plural scanning probes capable of observing the topography of a sample surface at high speed with a high resolution under the atmospheric pressure, comprising the steps of: a) vibrating, responsive to a

reference signal, a first actuator provided on each of the scanning probes; b) detecting a deflection amount of a cantilever provided with a tip at its free end; and c) transmitting a servo signal to a second actuator based on the deflection amount of the cantilever, wherein the cantilever provided on said each of the scanning probes and the first and second actuator are provided on the cantilever opposite to the free end where the tip is provided.

BRIEF DESCRIPTION OF THE DRAWINGS

The above and other objects and features of the present invention will become apparent from the following description of preferred embodiments given in conjunction with the accompanying drawings, in which:

Fig. 1 illustrates a schematic diagram of an atomic force microscope (AFM) capable of observing the topography of a sample surface in accordance with the present invention;

Fig. 2 shows a detailed diagram of a light beam scanner shown in Fig. 1;

Fig. 3 represents a cross-sectional view of a scanning probe of one preferred embodiment taken along a dotted line P-P' shown in Fig. 1;

Fig. 4 depicts a cross-sectional view of a scanning probe unit of another preferred embodiment in accordance with the present invention;

Fig. 5 exemplifies a block diagram of a driving control unit shown in Fig. 1; and

Fig. 6 is a flow chart for explaining the driving operation of the AFM in accordance with the present invention.

MODES OF CARRING OUT THE INVENTION

Preferred embodiments of the present invention will be described with reference to Figs. 1 to 6, which are given by way of illustration only and are not to be considered as limiting the present invention.

Referring to Fig. 1, there is illustrated a schematic block diagram of an atomic force microscope (AFM) 100 with plural scanning probes in accordance with the present invention, wherein the AFM 100 is capable of observing the topography of a sample surface at high speed with a high resolution under the atmospheric pressure. As shown in Fig. 1, the AFM 100 comprises a light beam source unit 110, a light beam scanner 120, a scanning probe unit 130, a light beam detection unit 140, a driving control unit 150 and a display unit 160.

The light beam source unit 110 emits a light beam, preferably, e.g., a laser beam, to the light beam scanner 120. The light beam source unit 110 may include, e.g., a laser diode (LD), a light emitting diode (LED), or the like. The light beam scanner 120 is mechanically connected to a supporting member (not shown) and is electrically connected through a line L16 to the driving control unit 150. The light beam scanner 120 receives the light beam emitted from the light beam source unit 110 to sequentially perform a scanning operation through a light scanning path A, B, or C on a corresponding scanning probe 131a, 131b, or 131c of the scanning probe unit 130, in response to a position signal provided through a line L16 from the driving control unit 150.

The scanning probe unit 130 includes three scanning probes 131a, 131b and 131c, each of which is electrically connected to the driving control unit 150 through a common line L14 and a line L15a, L15b, and L15c, respectively. For the sake of simplicity, it is illustrated that the scanning probe unit 130 is made of three scanning probes 131a to 131c

only, but those skilled in the art will well understand that the scanning probe unit 130 may be made of plural scanning probes, if necessary. The scanning probe unit 130 reflects the light beam emitted from the light beam source unit 110 through a light reflection path A', B', or C' to the light beam detection unit 140.

The light beam detection unit 140 is electrically connected through lines L13a and L13b to the driving control unit 150. The light beam detection unit 140 may be made of a switching block 144 and three photo-detectors 142a to 142c, the number of the photo-detectors being same as the number of the scanning probes 131a to 131c. Each photo-detector is electrically connected to the switching block 144. Each of photo-detectors 142a to 142c includes an electrical signal amplifier (not shown) and converts the light beam reflected by the scanning probe unit 130 into a corresponding electrical signal to amplify it to a predetermined signal level by using the electrical signal amplifier. The display unit 160 is electrically coupled to the driving control unit 150.

Referring to Fig. 2, there is shown a detailed diagram of the light beam scanner 120 illustrated in Fig. 1. As shown in Fig. 2, the light beam scanner 120 includes a first electrode 210, an electro-displacive layer 220, a second electrode 230, a total mirror 240 and a variable voltage source 250. The electro-displacive layer 220 is inserted between the first electrode 210 and the second electrode 230. The total mirror 240 is deposited on the second electrode 230, opposite to the electro-displacive layer 220. The variable voltage source 250, responsive to the position signal inputted thereto, provides the first and second electrode 210 and 230 with a predetermined voltage in accordance with the position signal level. As well known in the art, the electro-displacive layer 220 may be deflected depending on a voltage level supplied to the first and second electrode 210 and 230. In other words, by changing

the voltage level inputted to the first and second electrode 210 and 230, the scanning angle of the light beam incident to the total mirror 240 can be varied to allow the light beam to propagate through one of the light scanning paths A, B and C. Such operation will be apparent to the skilled person in the art. For example, if the light beam scanned by the light beam scanner 120 propagates through the light scanning path A, the light beam is reflected by the scanning probe 131a of the scanning probe unit 130 to be transmitted to the photo-detector 142a of the light beam detection unit 140 through the light reflection path A'. Otherwise, the light beam will be reflected by the scanning probe 131b or 131c to be transmitted to the photo-detector 142b or 142c of the light beam detection unit 140 through the light reflection path B' or C'.

Referring to Fig. 3, there is illustrated a cross-sectional view of the scanning probe 131a of the scanning probe unit 130 taken along a dotted line P-P' shown in Fig. 1. The structures of the scanning probes 131a to 131c of the scanning probe unit 130 are identical to each other. The scanning probe 131a is made of a bulk-type actuator 310a, a thin-film actuator 320a, a cantilever 330a, a tip 340a and a fixing member 350a placed between the bulk-type actuator 310a and the cantilever 330a, wherein the fixing member 350a is attached to a supporting frame or substrate (not shown). The bulk-type actuator 310a and the thin-film actuator 320a may be fabricated as well-known structure in which an electro-displacive material is inserted between two electrodes receiving an external signal. The electro-displacive material may be deflected depending on the external signal level provided to the two electrodes.

A sample 360 is held on a fine adjustment stage (not shown) capable of independently being driven in X-, Y- and/or Z-axis directions. For the sake of simplicity, the detailed description of the fine adjustment stage operation will be omitted. The cantilever 330a is disposed above the

fine adjustment stage.

The tip 340a, which can be made by employing various techniques well known in the art, is provided on a free end of the cantilever 330a and can be shifted in a normal direction, i.e., Z-axis direction, with respect to the surface of the sample 360 depending on the inter-atomic force (so-called as the Van der Waals' force) between the surface of the sample 360 to be observed and the tip 340a.

Opposite to the free end, the thin-film actuator 320a is integrated on the cantilever 330a. The thin-film actuator 320a may be fabricated together with the cantilever 330a. The thin-film actuator 320a serves to perform a positioning operation in response to a servo signal provided through a line L15a from the driving control unit 150. The positioning operation is to restore a deflection state of the cantilever 330a to an equilibrium state thereof at a measurement point of the sample surface, after the cantilever 330a is deflected in the Z-axis direction at the measurement point by the inter-atomic force between the tip 340a and the sample surface to be observed. The equilibrium state of the cantilever 330a is a non-deflection state thereof without affecting the current position of the cantilever 330a at the measurement point. The positioning operation will prevent the cantilever 330a from being extremely deflected, which may result in a cracking thereof.

The bulk-type actuator 310a is placed on the fixing member 350a. Alternatively, the bulk-type actuator 310a may be directly integrated on the cantilever 330a. In this case, the bulk-type actuator 310a will also play the role of the fixing member 350a. The bulk-type actuator 310a serves to allow the cantilever 330a to perform a tapping operation. The tapping operation is an operation in which the tip 340a provided on the free end of the cantilever 330a periodically comes in contact with and then off the surface of the sample 360 to be observed with a constant time period. In order to allow the cantilever 330a to perform the tapping operation,

the bulk-type actuator 310a, responsive to a reference signal transmitted through a line L14 from the driving control unit 150, vibrates in the Z-axis direction with a same frequency as that of the reference signal, wherein the frequency of the reference signal is preferably, e.g., several hundreds kHz. Such operation is also referred to as, e.g., a tapping mode. The tapping mode is known as an intermediate mode between a contact mode and a non-contact mode. The contact mode is a state in which the tip 340a comes in contact with the sample surface, whereas the non-contact mode is a state in which the tip 340a is off the sample surface.

When the bulk-type actuator 310a vibrates in the Z-axis direction, the fixing member 350a vibrates in the same direction with the same frequency as the bulk-type actuator 310a. When the fixing member 350a vibrates, the cantilever 330a fixed thereon also vibrates so that the tip 340a vibrates in the Z-axis direction with the same frequency as the bulk-type actuator 310a. When impurities, e.g., dusts, drops of water and the like, which may exist on the sample surface, stick to the tip 340a under the atmospheric pressure, the cantilever 330a in the tapping mode can remove them from the tip 340a. In other words, by employing the tapping mode, an image representing the topography of the surface of the sample 360 to be observed can be accurately obtained by removing the influence of the impurities degrading the quality of the image.

Referring to Fig. 4, there is illustrated a cross-sectional view of a scanning probe unit 490 in accordance with another preferred embodiment of the present invention. The scanning probe unit 490 includes a supporting frame or substrate 410, a multiplicity of openings 470 and a plurality of scanning probes 400. The scanning probes 400 are arranged with N x M matrices, N and M being positive integers greater than 1, respectively. The width W of the opening 470 is determined by the incident and reflection

angle of the light beam emitted from the light beam source 110. Each scanning probe 400 contains a fixing member 420, a bulk-type actuator 430, a thin-film actuator 440, a cantilever 450 and a tip 460. Comparing to the scanning probe 131a shown in Fig. 3, the positions of the fixing member 420 and the bulk-type actuator 430 are reversed. However, the function and operation of the components included in the scanning probe 400 are identical to that of the components included in the scanning probe 131a shown in Fig. 3. By using the scanning probe unit 490, the operator will observe the topography of the sample surface in an easy and simple manners.

Referring to Fig. 5, there is illustrated a detailed diagram of the driving control unit 150 shown in Fig. 1 in accordance with the present invention. As shown in Fig. 5, the driving control unit 150 includes a position signal generation block 510, a filtering block 520, a displacement calculation block 530, a servo signal generation block 540, a switching block 550, a selection signal generation block 560 and a reference signal generation block 570.

The reference signal generation block 570 generates the reference signal to provide it through the line L14 to the displacement calculation block 530 and each of the bulk-type actuators 310a, 310b and 310c employed in the respective scanning probes 131a, 131b and 131c shown in Fig. 3. As described above, in response to the reference signal, the bulk-type actuators 310a, 310b and 310c allow the scanning probes 131a, 131b and 131c to perform the tapping operation.

The position signal generation block 510 detects the amplified signal transmitted through the line L13a from the light beam detection unit 140 shown in Fig. 1. For example, if the amplified signal is not detected, i.e., being at an initial state, the position signal generation block 510 generates an initial position signal to provide it through a line L16 to the light beam scanner 120 shown in Fig. 1, in order to change the scanning position of the light beam

scanner 120 to a first position corresponding to the initial state. The first position is the position in which the light beam scanner 120 scans the light beam from the light beam source unit 110 to the scanning probe 131a, i.e., a first scanning probe of the scanning probe unit 130. It is noted that the scanning probes 131a, 131b and 131c are respectively referred to as the first, second and third scanning probe. Also, the position signal generation block 510 provides the initial position signal to the selection signal generation block 560 through the line L16.

In response to the initial position signal, the selection signal generation block 560 generates a first selection signal to transmit it through the line L13b to the switching block 144 of the light beam detection unit 140 and the switching block 550. The switching block 144 of the light beam detection unit 140 selects the first photo-detector 142a in response to the first selection signal. The switching block 550 also selects a line L15a connected to the first scanning probe 131a in response to the first selection signal, wherein the selected line L15a provides a servo signal generated in the servo signal generation block 540 to the thin-film actuator 320a of the first scanning probe 131a.

The filtering block 520 may include a high-pass and low-pass filter (not shown) arranged in parallel. Alternatively, the filtering block 520 may include circuits and/or devices capable of filtering the amplified signal inputted from the light beam detection unit 140. The filtering block 520 cuts off a frequency component corresponding to that of the reference signal contained in the amplified signal provided through the line L13a to pass the remaining frequency component differing from the cut-off frequency component, i.e., a varied frequency component, contained in the amplified signal.

When the amplified signal is provided, the filtering block 520 filters the amplified signal to extract only a

varied frequency component thereof. The extracted frequency component includes information concerning the deflection of the cantilever 330a caused by the inter-atomic force between the surface of the sample 360 to be observed and the tip 340a and is transmitted to the displacement calculation block 530. The displacement calculation block 530 calculates a displacement ΔZ corresponding to the deflection amount of the cantilever 330a which varies depending on the inter-atomic force based on the frequency component of the reference signal and the extracted frequency component from the filtering block 520.

In other words, the displacement calculation block 530 calculates a frequency difference between the frequency component of the reference signal and the extracted frequency component, wherein the calculated frequency difference is directly related to the deflection amount of the cantilever 330a caused by the inter-atomic force between the tip 340a and the surface of the sample 360 to be observed. The calculated frequency difference is then provided through a line L17 to the servo signal generation block 540 and the display unit 160 shown in Fig. 1.

Depending on the calculated frequency difference, the servo signal generation block 540 generates the servo signal to drive the thin-film actuator 320a of the first scanning probe 131a for allowing the cantilever 330a to perform the positioning operation, as described above. The servo signal is then transmitted to the thin-film actuator 320a through the line L15a already selected by the first selection signal.

Referring back to Fig. 1, the display unit 160 may include, e.g., a computer reconstructing a two- or three-dimensional image representing the topography of the surface of the sample 360 to be observed based on the calculated frequency difference provided through the line L17 from the displacement calculation block 530 shown in Fig. 4, and a monitor capable of displaying the reconstructed image thereon. It should be noted that the operation sequence of

the driving control unit 150 has been described in association with the first scanning probe 131a of the scanning probe unit 130 but that of the driving control unit 150 associated with the remaining scanning probes of the scanning probe unit 130 is similar.

Now, the detailed description of the driving operation of the AFM in accordance with the present invention will be described with reference to Fig. 6.

At step S602, the reference signal generation block 570 shown in Fig. 4 provides the reference signal through the line L14 to the bulk-type actuators 310a, 310b and 310c and the displacement calculation block 530. And, in response to the reference signal, the bulk-type actuators 310a, 310b and 310c vibrate with the same frequency as the reference signal. Thus, as described above, the cantilevers 330a, 330b and 330c operate in the tapping mode so that the respective tips 340a, 340b and 340c provided on the corresponding cantilevers 330a, 330b and 330c vibrate with the same frequency as the bulk-type actuators 310a, 310b and 310c.

At step S604, the position signal generation block 510 generates an initial position signal to provide it to the light beam scanner 120 and the selection signal generation block 560 through the line L16. In response to the initial position signal, the light beam scanner 120 is put to a first position. Then, the selection signal generation block 560, responsive to the initial position signal, generates a first selection signal to transmit it to the switching block 144 of the light beam detection unit 140 shown in Fig. 1 and the switching block 550 illustrated in Fig. 4 through the line L13b. Thereafter, the switching block 144 selects the first photo-detector 142a for detecting a reflected light beam from the first scanning probe 131a. Also, the switching block 550 chooses the line L15a for providing the thin-film actuator 320a with the servo signal generated in the servo signal generation block 540.

At step S606, the light beam source unit 110 emits the

light beam, preferably, e.g., a laser beam, on the light beam scanner 120. Then, the light beam scanner 120 located at the initial position scans the light beam through the light scanning path A shown in Fig. 1 on the tip portion of the cantilever 330a of the first scanning probe 131a. The cantilever 330a of the first scanning probe 131a reflects the light beam to direct it to the first photo-detector 142a of the light beam detection unit 140 through the light reflection path A'.

At step S608, the first photo-detector 142a detects the reflected light beam provided thereto and converts same into a corresponding electrical signal. The electrical signal is then amplified to a predetermined signal level by the electrical signal amplifier employed in the first photo-detector 142a. The amplified signal is provided through the line L13a to the filtering block 520 and the position signal generation block 510 of the driving control unit 150.

At step S610, the filtering block 520 filters the amplified signal to extract a varied frequency component thereof. As described above, the extracted frequency component includes information regarding the deflection of the cantilever 330a of the first scanning probe 131a, wherein the extracted frequency component may be higher or lower than the frequency component of the reference signal used to vibrate the cantilever 330a of the first scanning probe 131a. Then, the extracted frequency component is provided from the filtering block 520 to the displacement calculation block 530.

At step S612, the displacement calculation block 530 computes the displacement ΔZ, which is directly related to the deflection amount of the cantilever 330a of the first scanning probe 131a in the Z-axis direction, by calculating a frequency difference between the frequency component of the reference signal from the reference signal generation block 570 and the extracted frequency component from the filtering block 520. Then, the displacement calculation

block 530 provides the computed displacement ΔZ through the line L17 to the servo signal generation block 540 and the display unit 160 shown in Fig. 1.

At step S614, the servo signal generation block 540 generates a servo signal based on the computed displacement ΔZ to transmit it to the switching block 550 which provides the servo signal to the thin-film actuator 320a of the first scanning probe 131a through the line L15a already selected in response to the first selection signal. The servo signal drives the thin-film actuator 320a of the first scanning probe 131a for allowing the cantilever 330a thereof to restore it to its equilibrium state at this measurement point without changing its current position. The frequency of the servo signal may be, preferably, e.g., several tens of kHz. Also, the display unit 160 displays thereon the image of, e.g., 2- or 3-dimensional, representing the topography of the observed sample surface based on the computed displacement ΔZ.

At step S616, the position signal generation block 510, in response to the amplified signal as the signal inputted to the filtering block 520 at step S610, generates a next position signal to provide it to the selection signal generation block 560 and the light beam scanner 120 through the line L16. The selection signal generation block 560 generates a second selection signal to transmit it to the switching block 550 and the light beam detection unit 140 through the line L13b. Similar to the case of the first selection signal, in response to the second selection signal, the switching block 550 selects the line L15b as the next one and the switching block 144 of the light beam detection unit 140 chooses the second photo-detector 142b as the next one.

At step S618, the process determines whether or not the sample surface scanning operation is completed. If the determination result is negative, the process proceeds to the step S620; and, if otherwise, it terminates the

procedure. At step S620, the light beam scanner 120 will be put to a next position corresponding to the second next position signal inputted through the line L16 from the position signal generation block 510. Thereafter, the process returns to step S606 and repeats the steps described above.

As described above, in accordance with the present invention, the image representing the topography of the surface of the sample to be observed can be accurately obtained at high speed with high resolution, even in the presence of the impurities existing on the surface of the sample under the atmospheric pressure. Also, the components forming the scanning probe may be fabricated in one process to constitute one unit in a compact size so that the manufacturing cost of the atomic force microscope with plural scanning probes will be effectively reduced and the AFM has a simple structure even if it employs plural scanning probes. It should be noted that the components' dimension forming the scanning probe are exaggerated on the drawings in behalf of a full understanding.

While the present invention has been described with respect to the particular embodiment, it will be apparent to those skilled in the art that various changes and modifications may be made without departing from the spirit and scope of the invention as defined in the following claims.

What is claimed is:

1. An atomic force microscope (AFM) capable of observing the topography of a sample surface at high speed with a high resolution under the atmospheric pressure, comprising:

a plurality of scanning probes for measuring the sample surface, wherein each of the scanning probes includes a cantilever having a tip and a first and a second actuator;

means for detecting a light beam reflected from said each of the scanning probes to convert same into a first signal in response to a second signal; and

means for driving the scanning probes by generating a third and a fourth signal and detecting information regarding the topography of the sample surface,

wherein the first actuator performs a tapping operation in response to the third signal, the second actuator performs a positioning operation in response to the fourth signal and the frequency of the third signal is higher than that of the fourth signal.

2. The AFM according to claim 1, further comprising:

means for emitting the light beam;

means for scanning the light beam to said each of the scanning probes under the control of the driving means; and

means for displaying thereon an image representing the topography of the sample surface.

3. The AFM according to claim 2, wherein the driving means includes:

means for filtering the first signal to extract a frequency component different from the frequency component of the third signal, wherein the extracted frequency component is directly related to the information regarding the topography of the sample surface;

means for generating the third signal to provide same to the first actuator;

means for generating the fourth signal to provide same to the second actuator;

means for generating the second signal based on the first signal, in order to control the light beam scanning means; and

means for calculating a displacement of the cantilever moved in a normal direction with respect to the sample surface to generate a sixth signal bearing the information based on the extracted frequency component.

4. The AFM according to claim 3, wherein the light beam scanning means scans the light beam to said each of the scanning probes depending on the second signal generated from the driving means.

5. The AFM according to claim 4, wherein the tip is provided on a free end of the cantilever.

6. The AFM according to claim 5, wherein the driving means further includes:

means for generating a fifth signal based on the second signal; and

a switching block for selecting an output terminal connected to the second actuator of said each of the scanning probes, in response to the fifth signal, thereby providing the fourth signal to the second actuator.

7. The AFM according to claim 6, wherein the first and the second actuator are provided on the cantilever opposite to the free end thereof where the tip is provided.

8. The AFM according to claim 7, wherein the first actuator is arranged on the cantilever opposite to the second actuator.

9. The AFM according to claim 8, wherein the detecting

means includes:

a plurality of photo-detectors for detecting and converting the light beam into the first signal; and

a multiplicity of signal amplifiers for amplifying the level of the first signal into a predetermined signal level,

wherein each of the photo-detectors is connected to at least one of the signal amplifiers.

10. The AFM according to claim 9, wherein the detecting means further includes a switching block for selecting one of the signal amplifiers in response to the fifth signal.

11. The AFM according to claim 10, wherein the calculation means computes a displacement corresponding to a deflection amount of the cantilever based on the extracted frequency component and the frequency component of the third signal to thereby generate the sixth signal, wherein the deflection of the cantilever is caused by the inter-atomic force between the tip and the sample surface to be observed.

12. The AFM according to claim 11, wherein the fourth signal drives the second actuator to perform a positioning operation, wherein the positioning operation restores a deflection state of the cantilever to an equilibrium state thereof at a measurement point on the sample surface without changing the current position of the cantilever.

13. The AFM according to claim 12, wherein the tapping operation is an operation in which the tip periodically comes in contact with and then off the sample surface with a constant time interval.

14. The AFM according to claim 13, wherein the image representing the topography of the sample surface is reconstructed based on the sixth signal.

15. The AFM according to claim 14, wherein the sixth signal corresponds to the deflection amount of the cantilever.

16. An atomic force microscope (AFM) capable of observing the topography of a sample surface at high speed with a high resolution under the atmospheric pressure, comprising:

a scanning probe matrix having N x M scanning probes thereon for measuring the sample surface, wherein each of the scanning probes includes a cantilever having a tip and a first and a second actuator, N and M being positive integers greater than 1, respectively;

means for detecting a light beam reflected from said each of the scanning probes to convert same into an electrical signal; and

means for driving the scanning probes by generating a reference and a servo signal and detecting information regarding the topography of the sample surface,

wherein the first actuator performs a tapping operation in response to the reference signal, the second actuator performs a positioning operation in response to the servo signal and the frequency of the reference signal is higher than that of the servo signal.

17. The AFM according to claim 16, further comprising:

means for emitting the light beam;

means for scanning the light beam to said each of the scanning probes under the control of the driving means; and

means for displaying thereon an image representing the topography of the sample surface.

18. The AFM according to claim 17, wherein the driving means includes:

means for filtering the electrical signal to extract a frequency component different from the frequency component of the third signal, wherein the extracted frequency

component is directly related to the information regarding the topography of the sample surface;

means for generating the reference signal to provide same to the first actuator;

means for generating the servo signal to provide same to the second actuator;

means for generating a position signal based on the electrical signal, in order to control the light beam scanning means; and

means for calculating a displacement of the cantilever moved in a normal direction with respect to the sample surface to generate a displacement signal bearing the information based on the extracted frequency component.

19. The AFM according to claim 18, wherein the light beam scanning means scans the light beam to said each of the scanning probes depending on the position signal.

20. The AFM according to claim 19, wherein the scanning probe matrix includes a same number of openings as the number of the scanning probes.

21. The AFM according to claim 20, wherein the width of each of the openings is determined by an incidence and a reflection angle of the light beam.

22. The AFM according to claim 21, wherein the tip is provided on a distal end of the cantilever.

23. The AFM according to claim 22, wherein the driving means further includes:

means for generating the selection signal based on the position signal; and

a switching block for selecting an output terminal connected to the second actuator of said each of the scanning probes, in response to the selection signal,

thereby providing the servo signal to the second actuator.

24. The AFM according to claim 23, wherein the first and the second actuator are provided on the cantilever opposite to the distal end thereof where the tip is provided.

25. The AFM according to claim 24, wherein the first actuator is arranged on the cantilever opposite to the second actuator.

26. The AFM according to claim 25, wherein the detecting means includes:

a plurality of photo-detectors for detecting the light beam and converting same into the electrical signal; and

a multiplicity of signal amplifiers for amplifying the level of the electrical signal to a predetermined signal level,

wherein each of the photo-detectors is connected to at least one of the signal amplifiers.

27. The AFM according to claim 26, wherein the detecting means further includes a switching block for selecting one of the signal amplifiers in response to the selection signal.

28. The AFM according to claim 27, wherein the calculation means computes a displacement corresponding to a deflection amount of the cantilever based on the extracted frequency component and the frequency component of the reference signal to thereby generate the displacement signal, wherein the deflection of the cantilever is caused by the inter-atomic force between the tip and the sample surface to be observed.

29. The AFM according to claim 28, wherein the servo signal drives the second actuator to perform a positioning operation, wherein the positioning operation restores a

deflection state of the cantilever to an equilibrium state thereof at a measurement point on the sample surface without changing the current position of the cantilever.

30. The AFM according to claim 29, wherein the tapping operation is an operation in which the tip periodically comes in contact with and then off the sample surface with a constant time interval.

31. The AFM according to claim 30, wherein the image representing the topography of the sample surface is reconstructed based on the displacement signal.

32. The AFM according to claim 31, wherein the displacement signal corresponds to the deflection amount of the cantilever.

33. A method for driving an atomic force microscope (AFM) with plural scanning probes capable of observing the topography of a sample surface at high speed with a high resolution under the atmospheric pressure, comprising the steps of:

a) vibrating, responsive to a reference signal, a first actuator provided on each of the scanning probes;

b) detecting a deflection amount of a cantilever provided with a tip at its free end; and

c) transmitting a servo signal to a second actuator based on the deflection amount of the cantilever,

wherein the cantilever is provided on said each of the scanning probes and the first and second actuator are provided on the cantilever opposite to the free end where the tip is provided.

34. The method according to claim 33, wherein the step b) includes the steps of:

b1) emitting a light beam toward a light beam scanner;

b2) generating a position signal for locating the light beam scanner to a predetermined position where the light beam is directed to one of the scanning probes;

b3) detecting the light beam reflected from the tip portion of the cantilever; and

b4) converting the reflected light beam into an electrical signal to extract a frequency component thereof, wherein the extracted frequency component is different from the frequency component of the reference signal.

35. The method according to claim 34, wherein the extracted frequency component includes the information regarding the deflection of the cantilever.

36. The method according to claim 35, wherein the step c) includes the steps of:

c1) calculating a frequency component difference between the extracted frequency component and the frequency component of the reference signal; and

c2) generating the servo signal having a frequency corresponding to the calculated frequency component difference.

37. The method according to claim 36, wherein the calculated frequency component difference is directly related to the deflection amount of the cantilever.

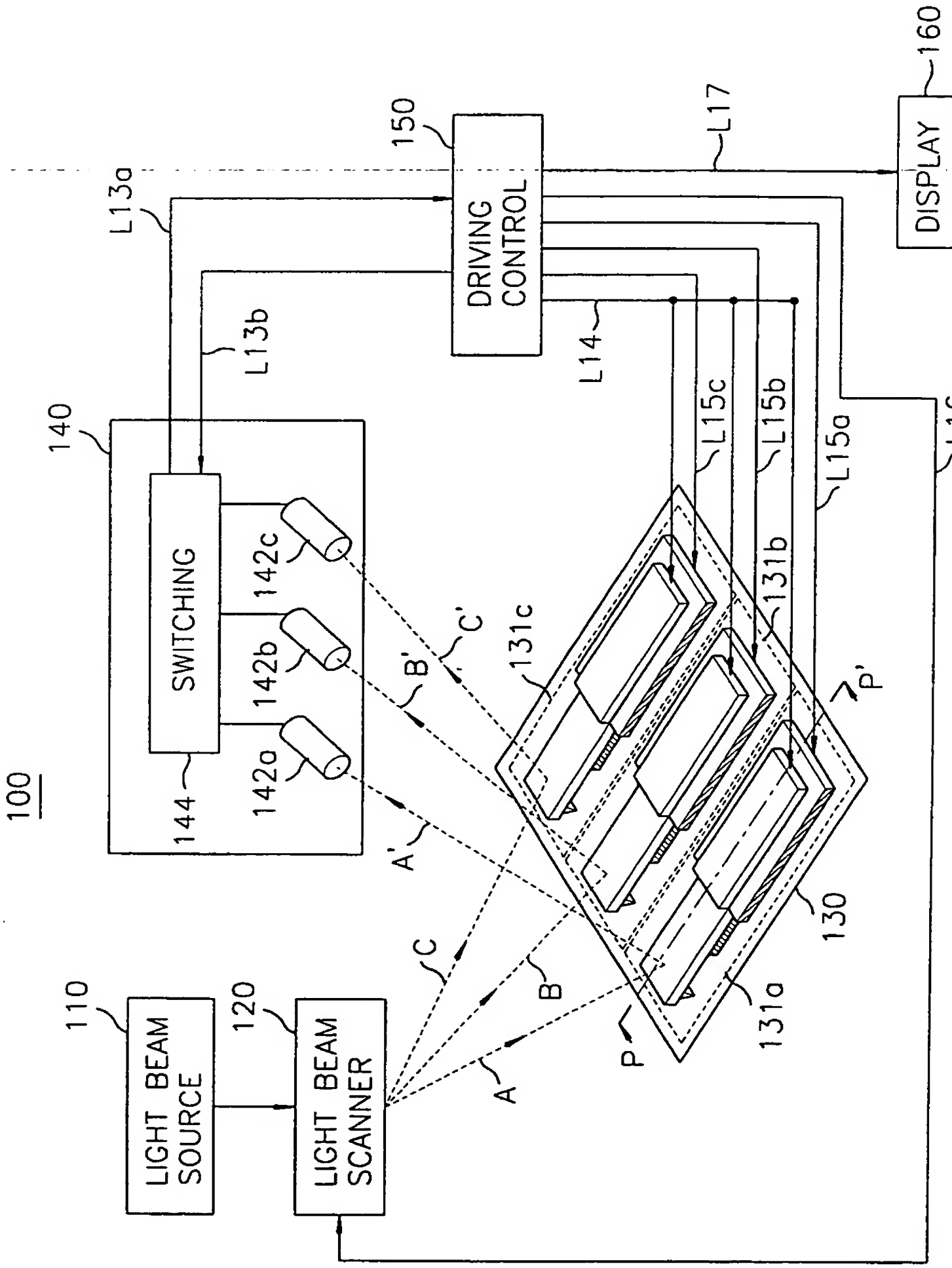
38. The method according to claim 37, wherein the servo signal drives the second actuator to perform a positioning operation, wherein the positioning operation restores a deflection state of the cantilever to an equilibrium state thereof at a measurement point on the sample without changing the current position of the cantilever.

39. The method according to claim 38, wherein the first actuator is arranged on the cantilever opposite to the

second actuator.

40. The method according to claim 39, wherein the first actuator performs a tapping operation in response to the reference signal, wherein the tapping operation is an operation in which the tip periodically comes in contact with and then off the sample surface with a constant time interval.

FIG. 1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LIGHT BEAM SCANNER
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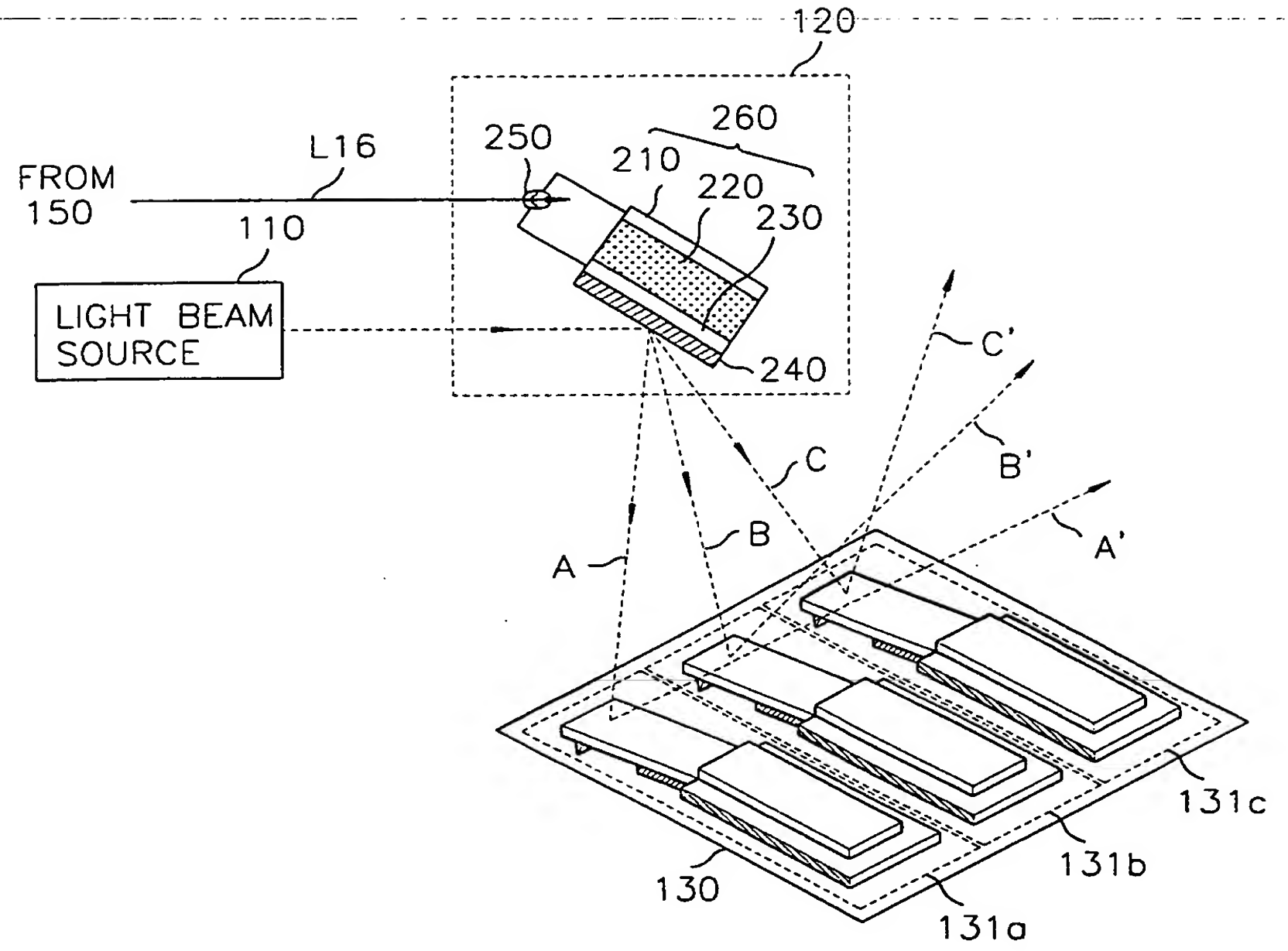
131a
131b
131c
140
142a
142b
142c
144
SWITCHING
150
DRIVING CONTROL
160
DISPLAY
L13a
L13b
L14
L15a
L15b
L15c
L16
L17
A
A'
B
B'
C
C'
P
P'

FIG.2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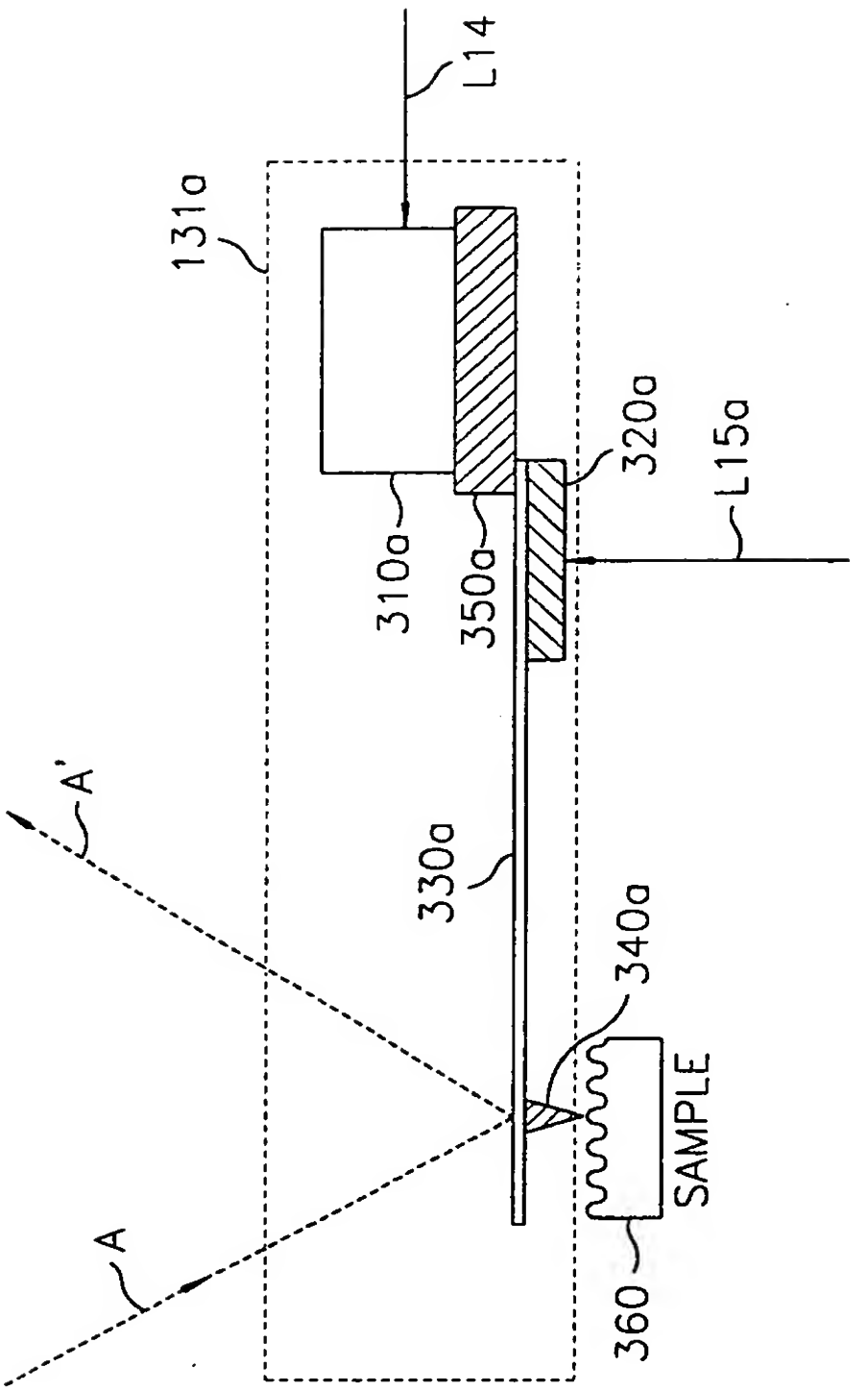
131c
131b
131a
130

FIG.3



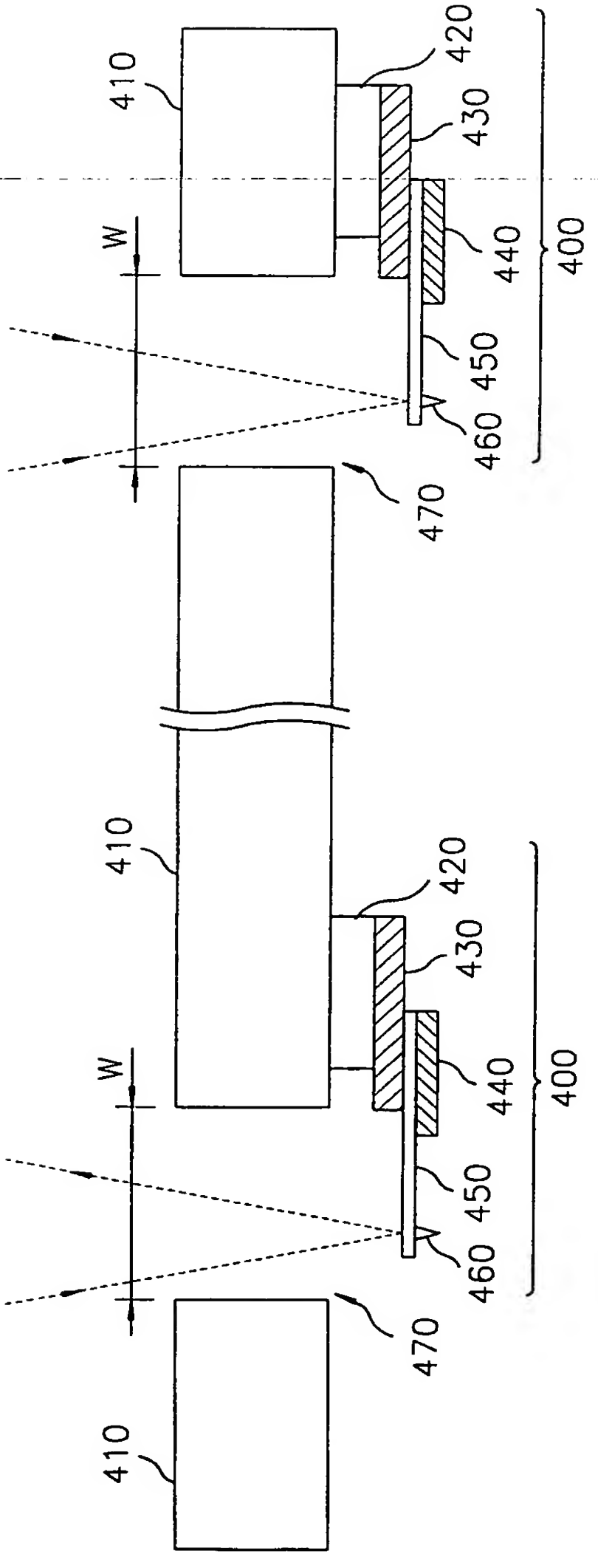

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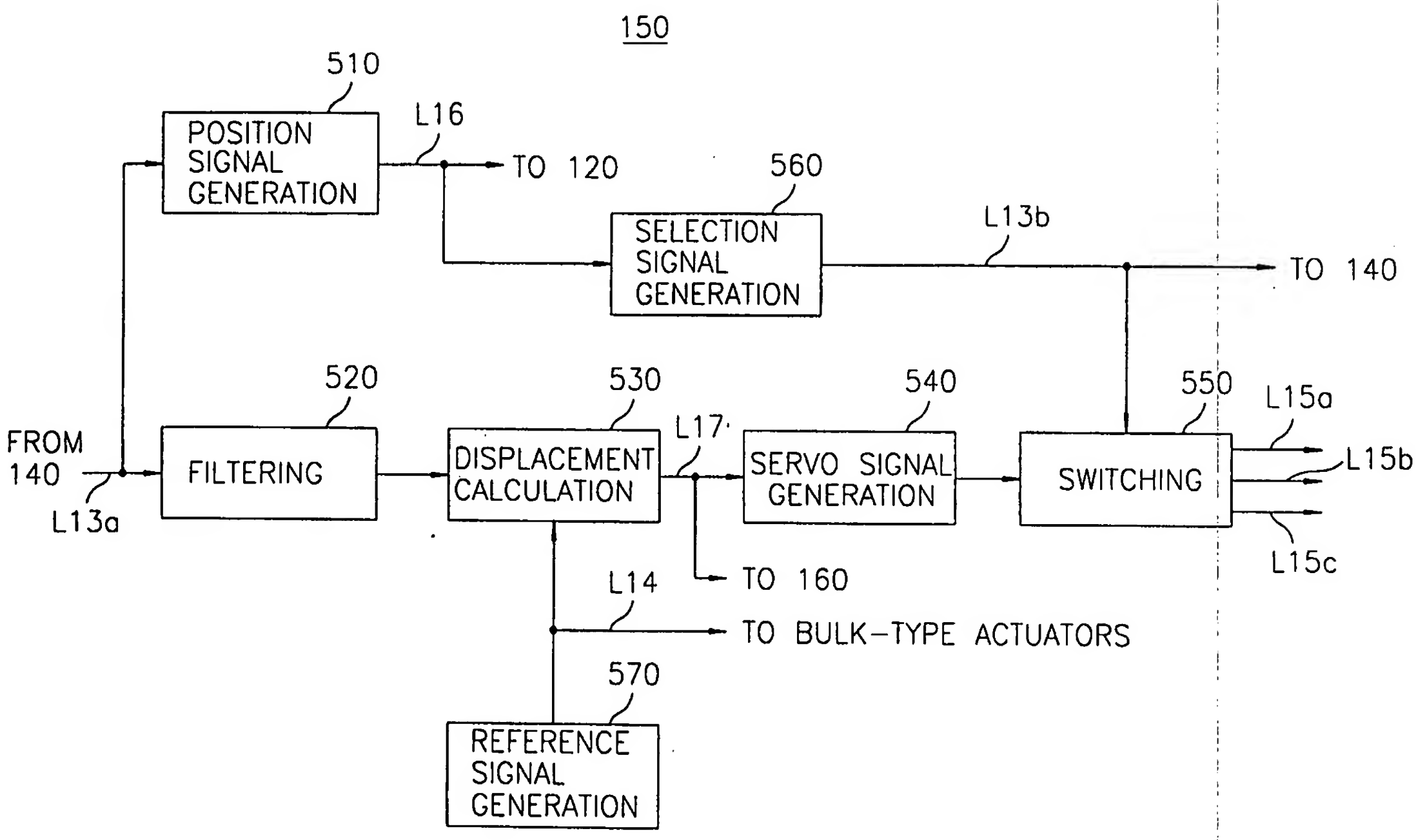
FIG. 4

FIG.5



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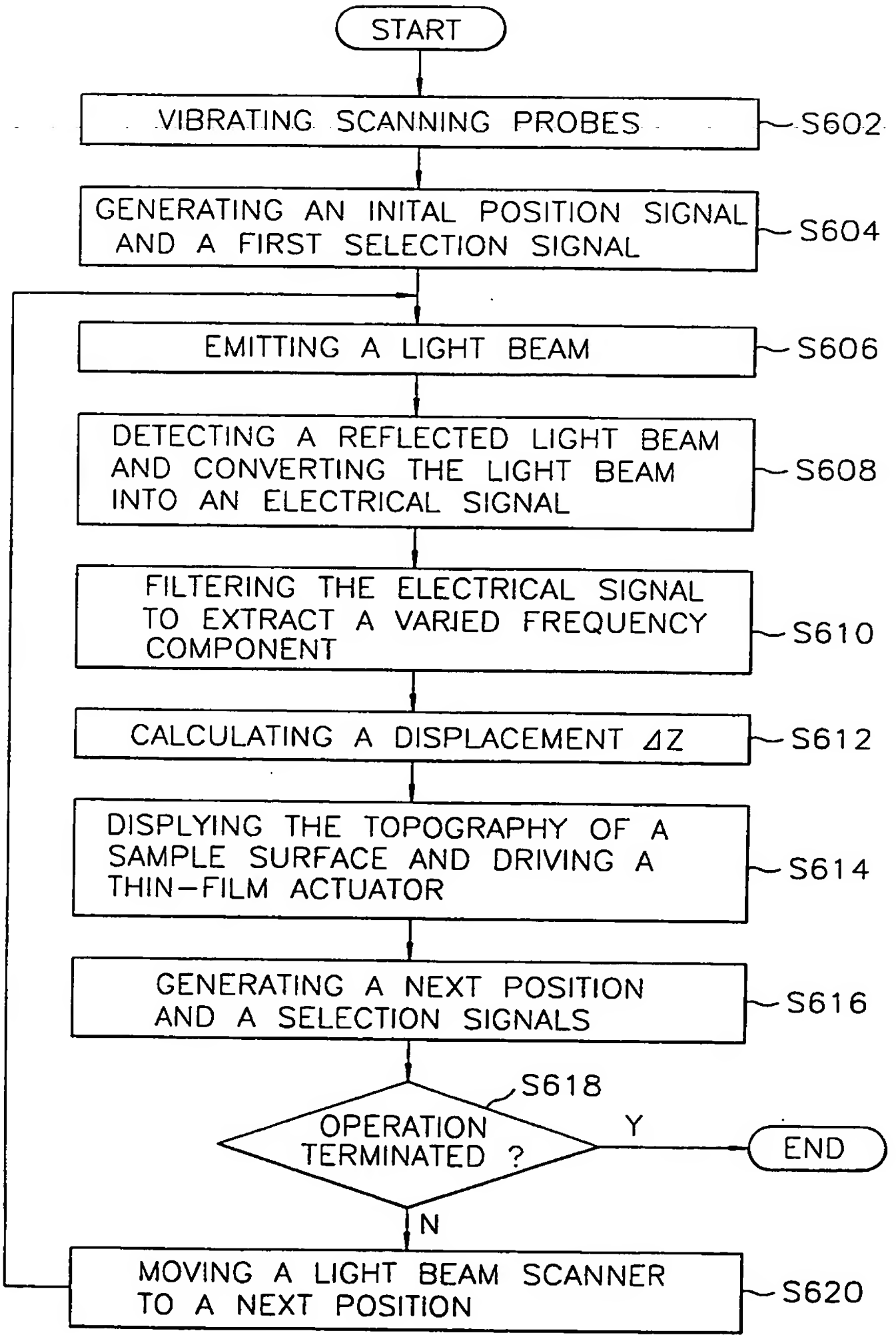
PCT/KR00/00564

FIG.6


START
VIBRATING SCANNING PROBES
S602
GENERATING AN INITAL POSITION SIGNAL AND A FIRST SELECTION SIGNAL
S604
EMITTING A LIGHT BEAM
S606
DETECTING A REFLECTED LIGHT BEAM AND CONVERTING THE LIGHT BEAM INTO AN ELECTRICAL SIGNAL
S608
FILTERING THE ELECTRICAL SIGNAL TO EXTRACT A VARIED FREQUENCY COMPONENT
S610
CALCULATING A DISPLACEMENT ΔZ
S612
DISPLYING THE TOPOGRAPHY OF A SAMPLE SURFACE AND DRIVING A THIN-FILM ACTUATOR
S614
GENERATING A NEXT POSITION AND A SELECTION SIGNALS
S616
S618
OPERATION TERMINATED ?
Y
END
N
MOVING A LIGHT BEAM SCANNER TO A NEXT POSITION
S620

PATENT COOPERATION TREATY

PCT

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference	FOR FURTHER ACTION	see Notification of Transmittal of International Search Report (Form PCT/ISA/220) as well as, where applicable, item 5 below.
PEA00613/DWE		
International application No.	International filing date (*day/month/year*)	(Earliest) Priority Date (*day/month/year*)
PCT/KR 00/00564	31 May 2000 (31.05.2000)	5 June 1999 (05.06.1999)
Applicant		
Daewoo Electronics Co., Ltd. et al.		

This international search report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This international search report consists of a total of 4 sheets.

☐ It is also accompanied by a copy of each prior art document cited in this report.

1. Basis of the report

a. With regard to the **language**, the international search was carried out on the basis of the international application in the language in which it was filed, unless otherwise indicated under this item.

☐ the international search was carried out on the basis of a translation of the international application furnished to this Authority (Rule 23.1(b)).

b. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international search was carried out on the basis of the sequence listing:

☐ contained in the international application in written form.

☐ filed together with the international application in computer readable form.

☐ furnished subsequently to this Authority in written form.

☐ furnished subsequently to this Authority in computer readable form.

☐ the statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.

☐ the statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

2. ☐ **Certain claims were found unsearchable** (See Box I).

3. ☐ **Unity of invention is lacking** (See Box II).

4. With regard to the **title**,

☒ the text is approved as submitted by the applicant.

☐ the text has been established by this Authority to read as follows:

5. With regard to the **abstract**,

☒ the text is approved as submitted by the applicant.

☐ the text has been established, according to Rule 38.2(b), by this Authority as it appears in Box III. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.

6. The figure of the **drawings** to be published with the abstract is Figure No.: 1

☒ as suggested by the applicant. ☐ None of the figures.

☐ because the applicant failed to suggest a figure.

☐ because this figure better characterizes the invention.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR 00/00564

CLASSIFICATION OF SUBJECT MATTER

IPC[7]: G01N 13/16; G01B 7/34

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC[7]: G01N 13/00, G01B 7/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

WPI

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5723775 A (S. WATANABE) 3 March 1998 (03.03.98) abstract; column 4, line 39 to column 5, line 16; claims; fig. 1,2,4,5 to 10.	1,2,3,5,7,11, 33,34
A	US 5468959 A (T. TOMDA) 21 November 1995 (21.11.95) abstract; column 3, line 63 to column 5, line 6; claims; fig.1	1,2,5,11,33,34
A	US 5338932 A (N. D. THEODORE) 16 August 1994 (16.08.94) totality.	1,2,5,33,34
A	EP 0884617 A1 (SEIKO INSTRUMENTS) 16 December 1998 (16.12.98) abstract; claims; fig. 1 to 22.	1,2,5,11,33,34
A	EP 0846932 A2 (SEIKO INSTRUMENTS) 10 June 1998 (10.06.98) abstract; claims; fig. 1 to 7.	1,2,5,11,33,34
A	EP 0759536 A1 (MITSUBISHI) 26 February 1997 (26.02.97) abstract; pages, lines 3 to 10; claims; fig. 1 to 14.	1,2,5,11,33,34

☒ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:
„A" document defining the general state of the art which is not considered to be of particular relevance
„E" earlier application or patent but published on or after the international filing date
„L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
„O" document referring to an oral disclosure, use, exhibition or other means
„P" document published prior to the international filing date but later than the priority date claimed

„T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
„X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
„Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
„&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
28 August 2000 (28.08.2000)	9 October 2000 (09.10.2000)
Name and mailing adress of the ISA/AT Austrian Patent Office Kohlmarkt 8-10; A-1014 Vienna Facsimile No. 1/53424/535	Authorized officer Erber Telephone No. 1/53424/382

INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR 00/00564

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 0510895 A2 (CHNOW KABUSHIKI) 28 October 1992 (28.10.92) totality.	1,2,4,5,11, 16, 17,19,22,
A	EP 0397116 A1 (AMERSHAM INTERNAT) 14 November 1990 (14.11.90) abstract; column 10, line 14 to column 12, line 46; claims; fig. 1,3,6,9,10.	1,2,5,16,17,19, 28,31,32-34
A	EP 0394962 A2 (OLYMPUS) 31 October 1990 (31.10.90) abstract; claims; fig. 1,2,8 to 12.	1,2,5,33,34

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.
PCT/KR 00/00564

Patent document cited in search report			Publication date	Patent family member(s)			Publication date
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				JP	B2	2791121	27-08-1998
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				US	A	5432346	11-07-1995
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EP	B1	510895	28-10-1998	CA	C	2066343	03-10-1995
				DE	C0	69227397	03-12-1998
				DE	T2	69227397	29-04-1999
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				JP	B2	3000492	17-01-2000
				US	A	5260926	09-11-1993
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				EP	B1	652414	02-06-1999
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				JP	B2	3047030	29-05-2000
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US	A	5468959	21-11-1995	DE	C0	69414896	14-01-1999
				DE	T2	69414896	22-04-1999
				EP	A1	616192	21-09-1994
				EP	B1	616192	02-12-1998
				JP	A2	6273155	30-09-1994
				JP	B2	2743761	22-04-1998
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INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR 00/00564

CLASSIFICATION OF SUBJECT MATTER

IPC[7]: G01N 13/16; G01B 7/34

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC[7]: G01N 13/00, G01B 7/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

WPI

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5723775 A (S. WATANABE) 3 March 1998 (03.03.98) abstract; column 4, line 39 to column 5, line 16; claims; fig. 1,2,4,5 to 10.	1,2,3,5,7,11, 33,34
A	US 5468959 A (T. TOMDA) 21 November 1995 (21.11.95) abstract; column 3, line 63 to column 5, line 6; claims; fig.1	1,2,5,11,33,34
A	US 5338932 A (N. D. THEODORE) 16 August 1994 (16.08.94) totality.	1,2,5,33,34
A	EP 0884617 A1 (SEIKO INSTRUMENTS) 16 December 1998 (16.12.98) abstract; claims; fig. 1 to 22.	1,2,5,11,33,34
A	EP 0846932 A2 (SEIKO INSTRUMENTS) 10 June 1998 (10.06.98) abstract; claims; fig. 1 to 7.	1,2,5,11,33,34
A	EP 0759536 A1 (MITSUBISHI) 26 February 1997 (26.02.97) abstract; pages, lines 3 to 10; claims; fig. 1 to 14.	1,2,5,11,33,34

☒ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

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„O" document referring to an oral disclosure, use, exhibition or other means
„P" document published prior to the international filing date but later than the priority date claimed

„T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
„X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
„Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
„&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
28 August 2000 (28.08.2000)	9 October 2000 (09.10.2000)
Name and mailing adress of the ISA/AT Austrian Patent Office Kohlmarkt 8-10; A-1014 Vienna Facsimile No. 1/53424/535	Authorized officer Erber Telephone No. 1/53424/382

Form PCT/ISA/210 (second sheet) (July 1998)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR 00/00564

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 0510895 A2 (CHNOW KABUSHIKI) 28 October 1992 (28.10.92) totality.	1,2,4,5,11, 16, 17,19,22,
A	EP 0397116 A1 (AMERSHAM INTERNAT) 14 November 1990 (14.11.90) abstract; column 10, line 14 to column 12, line 46; claims; fig. 1,3,6,9,10.	1,2,5,16,17,19, 28,31,32-34
A	EP 0394962 A2 (OLYMPUS) 31 October 1990 (31.10.90) abstract; claims; fig. 1,2,8 to 12.	1,2,5,33,34

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.
PCT/KR 00/00564

Patent document cited in search report			Publication date	Patent family member(s)			Publication date
EP	A2	394962	31-10-1990	DE	C0	69010552	18-08-1994
EP	A3	394962	27-12-1991	DE	T2	69010552	10-11-1994
EP	B1	394962	13-07-1994	JP	A2	3102209	26-04-1991
				US	A	5260824	09-11-1993
				JP	A2	3071001	26-03-1991
				JP	B2	2791121	27-08-1998
				JP	A2	2281103	16-11-1990
EP	A2	397116	14-11-1990	DE	C0	69024529	15-02-1996
EP	A3	397116	14-07-1993	DE	T2	69024529	29-08-1996
EP	B1	397116	03-01-1996	JP	A2	2293622	04-12-1990
				JP	B2	2686645	08-12-1997
				US	A	5432346	11-07-1995
EP	A2	510895	28-10-1992	AT	E	172810	15-11-1998
EP	A3	510895	01-06-1994	CA	AA	2066343	23-10-1992
EP	B1	510895	28-10-1998	CA	C	2066343	03-10-1995
				DE	C0	69227397	03-12-1998
				DE	T2	69227397	29-04-1999
				JP	A2	4321955	11-11-1992
				JP	B2	3000492	17-01-2000
				US	A	5260926	09-11-1993
EP	A1	759536	26-02-1997	DE	C0	69604634	18-11-1999
EP	B1	759536	13-10-1999	JP	A2	9061442	07-03-1997
				KR	B1	215526	16-08-1999
				US	A	5656809	12-08-1997
EP	A2	846932	10-06-1998	DE	C0	69418821	08-07-1999
				DE	T2	69418821	23-09-1999
				EP	A1	652414	10-05-1995
				EP	B1	652414	02-06-1999
				JP	A2	7128039	19-05-1995
				JP	B2	3047030	29-05-2000
EP	A1	884617	16-12-1998	JP	B2	2704601	26-01-1998
				CA	AA	2120975	13-10-1994
				DE	C0	69425456	14-09-2000
				EP	A1	622652	02-11-1994
				EP	B1	622652	09-08-2000
				JP	A2	7174542	14-07-1995
US	A	5338932	16-08-1994			none	
US	A	5468959	21-11-1995	DE	C0	69414896	14-01-1999
				DE	T2	69414896	22-04-1999
				EP	A1	616192	21-09-1994
				EP	B1	616192	02-12-1998
				JP	A2	6273155	30-09-1994
				JP	B2	2743761	22-04-1998
US	A	5723775	03-03-1998	JP	A2	9021816	21-01-1997

The demand must be filed directly with the competent International Preliminary examining Authority or, if two or more Authorities are competent, with the one chosen by the applicant. The full name or two-letter code of that Authority may be indicated by th applicant on th line below:

IPEA/ AT

PCT

CHAPTER II

DEMAND

under Article 31 of the Patent Cooperation Treaty:
The undersigned requests that the international application specified below be the subject of international preliminary examination according to the Patent Cooperation Treaty and hereby elects all eligible States(except where otherwise indicates).

For International Preliminary Examining Authority use only

Identification of IPEA	Date of receipt of DEMAND

Box No. I IDENTIFICATION OF THE INTERNATIONAL APPLICATION		Applicant's or agent's file reference PEA00613/DWE
International application No. PCT/KR00/00564	International filing date(*day/month/year* 31 May 2000 (31.05.00)	(earliest)Priority date(*day/month/year*) 5 June 1999 (05.06.99)

Title of invention
ATOMIC FORCE MICROSCOPE AND DRIVING METHOD THEREFOR

Box No. II APPLICANT(S)

Name and address:(*Family name followed by given name: for a legal entity, full official designation. The address must include postal code and name of country.*)
DAEWOO ELECTRONICS CO., LTD.
686, Ahyeon-Dong, Mapo-Gu, Seoul 121-709,
Republic of Korea

Telephone No.:
Facsimile No.:
Teleprinter No.:

State(*that is, country*)of nationality:	State(*that is, country*)of residence:
KR	KR

Name and address:(*Family name followed by given name: for a legal entity, full official designation. The address must include postal code and name of country.*)
KIM, You Kwang
Advanced Display & MEMS Research Center, Daewoo Electronics Co., Ltd.,
686, Ahyeon-Dong, Mapo-Gu, Seoul 121-709, Republic of Korea

State(*that is, country*)of nationality:	State(*that is, country*)of residence:
KR	KR

Name and address:(*Family name followed by given name: for a legal entity, full official designation. The address must include postal code and name of country.*)
KIM, Sang Gook
Advanced Display & MEMS Research Center, Daewoo Electronics Co., Ltd.,
686, Ahyeon-Dong, Mapo-Gu, Seoul 121-709, Republic of Korea

State(*that is, country*)of nationality:	State(*that is, country*)of residence:
KR	KR

☒ Further applicants are indicated on a continuation sheet.

International application No
PCT/KR00/00564

Continuation of Box No. II APPLICANT(S)

If none of the following sub-boxes is used, this sheet should not be included in the demand.

Name and address: *(Family name followed by given name: for a legal entity, full official designation. The address must include postal code and name of country.)*

HWANG, Kyu Ho
Advanced Display & MEMS Research Center, Daewoo Electronics Co., Ltd.,
686, Ahyeon-Dong, Mapo-Gu, Seoul 121-709, Republic of Korea

State *(that is, country)* of nationality:	State *(that is, country)* of residence:
KR	KR

Name and address: *(Family name followed by given name: for a legal entity, full official designation. The address must include postal code and name of country.)*

State *(that is, country)* of nationality:	State *(that is, country)* of residence:

Name and address: *(Family name followed by given name: for a legal entity, full official designation. The address must include postal code and name of country.)*

State *(that is, country)* of nationality:	State *(that is, country)* of residence:

Name and address: *(Family name followed by given name: for a legal entity, full official designation. The address must include postal code and name of country.)*

State *(that is, country)* of nationality:	State *(that is, country)* of residence:

☐ Further applicants are indicated on a continuation sheet.

International application No
PCT/KR00/00564

Box No. III AGENT OR COMMON REPRESENTATIVE; OR ADDRESS FOR CORRESPONDENCE

The following person is [X] agent [ ] common representative

and [X] has been appointed earlier and represents the applicant(s) also for international preliminary examination.

[ ] is hereby appointed and any earlier appointment of (an) agent(s)/common representative is hereby revoked

[ ] is hereby appointed, specifically for the procedure before the International Preliminary Examining Authority, In addition to the agent(s)/common representative appointed earlier.

Name and address: *(Family name followed by given name: for a legal entity, full official designation. The address must include postal code and name of country.)*

JANG Seong Ku
17th Fl. KEC Building, 275-7 Yangjae-Dong, Seocho-Gu,
Seoul 137-130, Republic of Korea

Telephone No.: 82-2-589-0001

Facsimile No.: 82-2-589-0002

Teleprinter No.:

[ ] Address for correspondence: Mark this check-box where no agent or common representative is/has been appointed and the space above is used instead to indicate a special address to which correspondence should be sent.

Box No. IV BASIS FOR INTERNATIONAL PRELIMINARY EXAMINATION

Statement concerning amendments: *

1. The applicant wishes the international preliminary examination to start on the basis of:

[X] the international application as originally filed

the description
[ ] as originally filed
[ ] as amended under Article 34

the claims
[ ] as originally filed
[ ] as amended under Article 19(together with any accompanying statement)
[ ] as amended under Article 34

the drawings
[ ] as originally filed
[ ] as amended under Article 34

2. [ ] The applicant wishes any amendment to the claims under Article 19 to be considered as reversed.

3. [ ] The applicant wishes the start of the international preliminary examination to be postponed until the expiration of 20 months from the priority date unless the International preliminary examining Authority receives a copy of any amendments made under Article 19 or a notice from the applicant that he does not wish to make such amendments(Rule 69.1(d)). *(This check-box may be marked only where the time limit under Article 19 has not yet expired.)*

* Where no check-box is marked, international preliminary examination will start on the basis of the international application as originally filed or, where a copy of amendments to the claims under Article 19 and/or amendments of the international application under Article 34 are received by the International preliminary examining Authority before it has begun to draw up a written opinion or the international preliminary examination report, as so amended.

Language for the purposes of international preliminary examination: English

[X] which is the language in which the international application was filed.
[ ] which is the language of a translation furnished for the purposes of international search.
[ ] which is the language of publication of the international application.
[ ] which is the language of a translation (to be) furnished for the purposes of international preliminary examination..

Box No. V ELECTION OF STATES

The applicant hereby elects all eligible States*(that is, all States which have been designated and which are bound by Chapter II of the PCT)*

Excluding the following States which the applicant wishes not to elect:

International application No
PCT/KR00/00564

Box No. VI CHECK LIST

The demand is accompanied by the following elements, in the language referred to in Box No. IV, for the purposes of international preliminary examination:			For International Preliminary Examining Authority use only: received	Not received
1. translation of international application	:	sheets	☐	☐
2. amendments under Article 34	:	sheets	☐	☐
3. copy(or, where required, translation)of amendment under Article 19	:	sheets	☐	☐
4. copy(or, where required, translation)of Statement under Article 19	:	sheets	☐	☐
5. letter	:	sheets	☐	☐
6. other*(specify)*	:	sheets	☐	☐

The demand is also accompanied by the item(s) marked below:

1. ☒ fee calculation sheet
2. ☐ separate signed power of attorney
3. ☐ copy of general power of attorney; reference number, if any:
4. ☐ statement explaining lack of signature
5. ☐ nucleotide and or amino acid sequence listing in computer readable form
6. ☐ other*(specify)*:

Box No. VII SIGNATURE OF APPLICANT, AGENT OR COMMON REPRESENTATIVE

Next to each signature, indicate the name of th person signing and the capacity in which the person sings(if such capacity is not obvious from reading the demand).

Patent Attorney

JANG Seong Ku

For International Preliminary Examining Authority use only

1. Date of actual receipt of DEMAND:
2. Adjusted date of receipt of demand due to CORRECTIONS under Rule 60.1(b)
3. ☐ The date of receipt of the demand is AFTER the expiration of 19 months from the priority date and item 4 or 5, below, does not apply. ☐ The applicant has been informed accordingly.
4. ☐ The date of receipt of the demand is WITHIN the period of 19 months from the priority date as extended by virtue of Rule 80.5
5. ☐ Although the date of receipt of the demand is after the expiration of 19 months from the priority date, the delay in arrival is EXCUSED pursuant to rule 82

For International Bureau use only

Demand received from IPEA on:

See Notes to the demand form

4

PATENT COOPERATION TREATY

PCT

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference	FOR FURTHER ACTION	See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)
PEA00613/DWE		

International application No.	International filing date (*day/month/year*)	Priority Date (*day/month/year*)
PCT/KR 00/00564	31 May 2000 (31.05.2000)	5 June 1999 (05.06.1999)

International Patent Classification (IPC) or national classification and IPC

IPC[7]: G01N 13/16; G01B 7/34

Applicant

DAEWOO ELECTRONICS CO., LTD. et al.

1. This international preliminary examination report has been prepared by this International Preliminary Examination Authority and is transmitted to the applicant according to Article 36.

2. This REPORT consists of a total of 3 sheets, including this cover sheet.

   ☐ This report is also accompanied by ANNEXES, i.e., sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

   These annexes consist of a total of _____ sheets.

3. This report contains indications relating to the following items:

   I. ☒ Basis of the opinion

   II. ☐ Priority

   III. ☐ Non-establishment of opinion with regard to novelty, inventive step and industrial applicability

   IV. ☐ Lack of unity of invention

   V. ☒ Reasoned statement under Rule 66.2(a)(ii) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

   VI. ☐ Certain documents cited

   VII. ☐ Certain defects in the international application

   VIII. ☐ Certain observations on the international application

Date of submission of the demand	Date of completion of this report
2 January 2001 (02.01.2001)	4 September 2001 (04.09.2001)

Name and mailing address of the IPEA/AT	Authorized officer
Austrian Patent Office Kohlmarkt 8-10 A-1014 Vienna Facsimile No. 1/53424/200	ERBER Telephone No. 1/53424/410

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No.
PCT/KR 00/00564

I. Basis of the report

1. With regard to the **elements** of the international application:*

☒ the international application as originally filed

☐ the description:
pages _____ . as originally filed
pages _____ . filed with the demand
pages _____. filed with the letter of _____.

☐ the claims:
pages _____ . as originally filed
pages _____ . as amended (together with any statement) under Article 19
pages _____ . filed with the demand
pages _____. filed with the letter of _____.

☐ the drawings:
pages _____ . as originally filed
pages _____ . filed with the demand
pages _____ . filed with the letter of _____.

☐ the sequence listing part of the description:
pages _____ . as originally filed
pages _____ . filed with the demand
pages _____ . filed with the letter of _____.

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.
These elements were available or furnished to this Authority in the following language _____ which is:

☐ the language of a translation furnished for the purposes of international search (under Rule 23.1(b)).

☐ the language of publication of the international application (under Rule 48.3(b)).

☐ the language of the translation furnished for the purposes of international preliminary examination (under Rule 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

☐ contained in the international application in printed form.

☐ filed together with the international application in computer readable form.

☐ furnished subsequently to this Authority in written form.

☐ furnished subsequently to this Authority in computer readable form.

☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.

☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

4. ☐ The amendments have resulted in the cancellation of:

☐ the description, pages _____.

☐ the claims, Nos. _____.

☐ the drawings, sheets/fig _____.

5. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed, as indicated in the Supplemental Box (Rule 70.2(c)).**

** Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report since they do not contain amendments (Rules 70.16 and 70.17).*

*** Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.*

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No.
PCT/KR 00/00564

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Claims	1-40	YES
	Claims		NO
Inventive step (IS)	Claims	1-40	YES
	Claims		NO
Industrial applicability (IA)	Claims	1-40	YES
	Claims		NO

Citations and explanations (Rule 70.7)

The following documents have been cited in the Search Report:

D1: US5723775A
D2: US5468959A
D3: US5338932A
D4: EP0884617A1
D5: EP0846932A2
D6: EP0759536A1
D7: EP0510895A2
D8: EP0397116A1
D9: EP0394962A2

The documents cited in the search report merely describe the state of the art. None of them discloses an atomic force microscope resp. a method for driving an atomic force microscope comprising the features as recited in claim1 and the independent claims 16 and 33. In the subclaims there are disclosed further developments of the subject matter of claims 1, 16 resp. 33. Therefore the subject matter of all claims 1 to 40 can be considered to fulfil the requirements for novelty and inventive step.

Industrial applicability is given.

PATENT COOPERATION TREATY

From the
INTERNATIONAL PRELIMINARY EXAMINING AUTHORITY

To:
JANG Seong Ku
17th Fl., KEC Building,
#275-7, Yangjae-dong, Seocho-ku,
Seoul 137-130,
Republic of Korea

PCT

NOTIFICATION OF TRANSMITTAL OF INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Rule 71.1)

Date of mailing (day/month/year)	22 November 2001 (22.11.01)
Applicant's or agent's file reference	IMPORTANT NOTIFICATION
PEA00613/DWE	

International application No.	International filing date (day/month/year)	Priority Date (day/month/year)
PCT/ KR 00/00564	31 May 2000 (31.05.00)	5 June 1999 (05.06.99)

Applicant
DAEWOO ELECTRONICS CO., LTD. et al.

1. The applicant is hereby notified that this International Preliminary Examining Authority transmits herewith the international preliminary examination report and its annexes, if any, established on the international application.

2. A copy of of the report and its annexes, if any, is being transmitted to the International Bureau for communication to all the eleceted Offices.

3. Where required by any of the elected Offices, the Interational Bureau will prepare an English translation of the report (but not of any annexes) and will transmit such translation to those Offices.

4. **REMINDER**

The applicant must enter the national phase before each elected Office by performing certain acts (filing translations and paying national fees) within 30 months from the priority date (or later in some Offices) (Article 39(1)) (see also the reminder sent by the International Bureau with Form PCT/IB/301).

Where a translation of the international application must be furnished to an elected Office, that translation must contain a translation of any annexes to the international preliminary examination report. It is the applicant's responsibility to prepare and furnish such translation directly to each elected Office concerned.

For further details on the applicable time limits and requirements of the eleceted Offices, see Volume II of the PCT Applicant's Guide.

Name and mailing address of the IPEA/AT	Authorized officer
Austrian Patent Office Kohlmarkt 8-10 A-1014 Vienna Facsimile No. 1/53424/200	Wolf Telephone No. +43 / 1 / 53424 - 450

Form PCT/IPEA/416 (July 1992)

PATENT COOPERATION TREATY

PCT

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference	FOR FURTHER ACTION	See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)
PEA00613/DWE		

International application No.	International filing date (*day/month/year*)	Priority Date (*day/month/year*)
PCT/KR 00/00564	31 May 2000 (31.05.2000)	5 June 1999 (05.06.1999)

International Patent Classification (IPC) or national classification and IPC

IPC[7]: G01N 13/16; G01B 7/34

Applicant

DAEWOO ELECTRONICS CO., LTD. et al.

1. This international preliminary examination report has been prepared by this International Preliminary Examination Authority and is transmitted to the applicant according to Article 36.

2. This REPORT consists of a total of 3 sheets, including this cover sheet.

   ☐ This report is also accompanied by ANNEXES, i.e., sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

   These annexes consist of a total of _____ sheets.

3. This report contains indications relating to the following items:

   I. ☒ Basis of the opinion

   II. ☐ Priority

   III. ☐ Non-establishment of opinion with regard to novelty, inventive step and industrial applicability

   IV. ☐ Lack of unity of invention

   V. ☒ Reasoned statement under Rule 66.2(a)(ii) with regard to novelty, inventive step or industrial applicability: citations and explanations supporting such statement

   VI. ☐ Certain documents cited

   VII. ☐ Certain defects in the international application

   VIII. ☐ Certain observations on the international application

Date of submission of the demand	Date of completion of this report
2 January 2001 (02.01.2001)	4 September 2001 (04.09.2001)

Name and mailing address of the IPEA/AT	Authorized officer
Austrian Patent Office Kohlmarkt 8-10 A-1014 Vienna Facsimile No. 1/53424/200	ERBER Telephone No. 1/53424/410

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No.
PCT/KR 00/00564

I. Basis of the report

1. With regard to the **elements** of the international application:*

☒ the international application as originally filed

☐ the description:
pages _____ . as originally filed
pages _____ . filed with the demand
pages _____. filed with the letter of _____.

☐ the claims:
pages _____ . as originally filed
pages _____ . as amended (together with any statement) under Article 19
pages _____ . filed with the demand
pages _____. filed with the letter of _____.

☐ the drawings:
pages _____ . as originally filed
pages _____ . filed with the demand
pages _____ . filed with the letter of _____.

☐ the sequence listing part of the description:
pages _____ . as originally filed
pages _____ . filed with the demand
pages _____ . filed with the letter of _____.

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.
These elements were available or furnished to this Authority in the following language _____ which is:

☐ the language of a translation furnished for the purposes of international search (under Rule 23.1(b)).

☐ the language of publication of the international application (under Rule 48.3(b)).

☐ the language of the translation furnished for the purposes of international preliminary examination (under Rule 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

☐ contained in the international application in printed form.

☐ filed together with the international application in computer readable form.

☐ furnished subsequently to this Authority in written form.

☐ furnished subsequently to this Authority in computer readable form.

☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.

☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

4. ☐ The amendments have resulted in the cancellation of:

☐ the description, pages _____.

☐ the claims, Nos. _____.

☐ the drawings, sheets/fig _____.

5. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed, as indicated in the Supplemental Box (Rule 70.2(c)).**

* *Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report since they do not contain amendments (Rules 70.16 and 70.17).*

** *Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.*

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No.
PCT/KR 00/00564

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Claims	1-40	YES
	Claims		NO
Inventive step (IS)	Claims	1-40	YES
	Claims		NO
Industrial applicability (IA)	Claims	1-40	YES
	Claims		NO

Citations and explanations (Rule 70.7)

The following documents have been cited in the Search Report:

D1: US5723775A
D2: US5468959A
D3: US5338932A
D4: EP0884617A1
D5: EP0846932A2
D6: EP0759536A1
D7: EP0510895A2
D8: EP0397116A1
D9: EP0394962A2

The documents cited in the search report merely describe the state of the art. None of them discloses an atomic force microscope resp. a method for driving an atomic force microscope comprising the features as recited in claim1 and the independent claims 16 and 33. In the subclaims there are disclosed further developments of the subject matter of claims 1, 16 resp. 33. Therefore the subject matter of all claims 1 to 40 can be considered to fulfil the requirements for novelty and inventive step.

Industrial applicability is given.

PATENT COOPERATION TREATY

From the INTERNATIONAL BUREAU

PCT

To:

JANG, Seong, Ku
17th Floor, KEC Building, 275-7
Yangjae-Dong, Seocho-Ku
Seoul 137-130
RÉPUBLIQUE DE CORÉE

NOTIFICATION OF THE RECORDING OF A CHANGE

(PCT Rule 92bis.1 and Administrative Instructions, Section 422)

Date of mailing (day/month/year) 12 February 2001 (12.02.01)	
Applicant's or agent's file reference PEA00613/DWE	**IMPORTANT NOTIFICATION**
International application No. PCT/KR00/00564	**International filing date** (day/month/year) 31 May 2000 (31.05.00)

1. The following indications appeared on record concerning:

[X] the applicant [ ] the inventor [ ] the agent [ ] the common representative

Name and Address

DAEWOO ELECTRONICS CO., LTD.
686, Ahyeon-Dong
Mapo-Gu
Seoul 121-709
Republic of Korea

State of Nationality	State of Residence
KR	KR

Telephone No.

Facsimile No.

Teleprinter No.

2. The International Bureau hereby notifies the applicant that the following change has been recorded concerning:

[ ] the person [ ] the name [X] the address [ ] the nationality [ ] the residence

Name and Address

DAEWOO ELECTRONICS CO., LTD.
541, 5-Ga, Namdaemoon-Ro,
Jung-Gu
Seoul 100-095
Republic of Korea

State of Nationality	State of Residence
KR	KR

Telephone No.

Facsimile No.

Teleprinter No.

3. Further observations, if necessary:

4. A copy of this notification has been sent to:

[X] the receiving Office
[X] the International Searching Authority
[ ] the International Preliminary Examining Authority
[X] the designated Offices concerned
[ ] the elected Offices concerned
[ ] other:

The International Bureau of WIPO
34, chemin des Colombettes
1211 Geneva 20, Switzerland

Facsimile No.: (41-22) 740.14.35

Authorized officer

Lazar Joseph Panakal

Telephone No.: (41-22) 338.83.38

PCT

REQUEST

The undersigned requests that the present international application be processed according to the Patent Cooperation Treaty.

For receiving Office use only

International Application No.

International Filing Date

Name of receiving Office and "PCT International Application"

Applicant's or agent's file reference *(if desired) (12 characters maximum)* PEA00613/DWE

Box No. I TITLE OF INVENTION

ATOMIC FORCE MICROSCOPE AND DRIVING METHOD THEREFOR

Box No. II APPLICANT

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)*

DAEWOO ELECTRONICS CO., LTD.
686, Ahyeon-Dong, Mapo-Gu, Seoul 121-709,
Republic of Korea

☐ This person is also inventor.

Telephone No.

Facsimile No.

Teleprinter No.

State *(that is, country)* of nationality: KR

State *(that is, country)* of residence: KR

This person is applicant for the purposes of: ☐ all designated States ☒ all designated States except the United States of America ☐ the United States of America only ☐ the States indicated in the Supplemental Box

Box No. III FURTHER APPLICANT(S) AND/OR (FURTHER) INVENTOR(S)

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)*

KIM, You Kwang
Advanced Display & MEMS Research Center,
Daewoo Electronics Co., Ltd., 686, Ahyeon-Dong,
Mapo-Gu, Seoul 121-709, Republic of Korea

This person is:

☐ applicant only

☒ applicant and inventor

☐ inventor only *(If this check-box is marked, do not fill in below.)*

State *(that is, country)* of nationality: KR

State *(that is, country)* of residence: KR

This person is applicant for the purposes of: ☐ all designated States ☐ all designated States except the United States of America ☒ the United States of America only ☐ the States indicated in the Supplemental Box

☒ Further applicants and/or (further) inventors are indicated on a continuation sheet.

Box No. IV AGENT OR COMMON REPRESENTATIVE; OR ADDRESS FOR CORRESPONDENCE

The person identified below is hereby/has been appointed to act on behalf of the applicant(s) before the competent International Authorities as: ☒ agent ☐ common representative

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)*

JANG, Seong Ku
17th Fl., KEC Building, 275-7, Yangjae-Dong,
Seocho-Ku, Seoul 137-130, Republic of Korea

Telephone No. 82-2-589-0001

Facsimile No. 82-2-589-0002

Teleprinter No.

☐ **Address for correspondence:** Mark this check-box where no agent or common representative is/has been appointed and the space above is used instead to indicate a special address to which correspondence should be sent.

Continuation of Box No. III FURTHER APPLICANT(S) AND/OR (FURTHER) INVENTOR(S)

If none of the following sub-boxes is used, this sheet should not be included in the request.

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)*

KIM, Sang Gook
Advanced Display & MEMS Research Center,
Daewoo Electronics Co., Ltd., 686, Ahyeon-Dong,
Mapo-Gu, Seoul 121-709, Republic of Korea

This person is:
- [ ] applicant only
- [x] applicant and inventor
- [ ] inventor only *(If this check-box is marked, do not fill in below.)*

State *(that is, country)* of nationality: KR

State *(that is, country)* of residence: KR

This person is applicant for the purposes of:
- [ ] all designated States
- [ ] all designated States except the United States of America
- [x] the United States of America only
- [ ] the States indicated in the Supplemental Box

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)*

HWANG, Kyu Ho
Advanced Display & MEMS Research Center,
Daewoo Electronics Co., Ltd., 686, Ahyeon-Dong,
Mapo-Gu, Seoul 121-709, Republic of Korea

This person is:
- [ ] applicant only
- [x] applicant and inventor
- [ ] inventor only *(If this check-box is marked, do not fill in below.)*

State *(that is, country)* of nationality: KR

State *(that is, country)* of residence: KR

This person is applicant for the purposes of:
- [ ] all designated States
- [ ] all designated States except the United States of America
- [x] the United States of America only
- [ ] the States indicated in the Supplemental Box

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)*

This person is:
- [ ] applicant only
- [ ] applicant and inventor
- [ ] inventor only *(If this check-box is marked, do not fill in below.)*

State *(that is, country)* of nationality:

State *(that is, country)* of residence:

This person is applicant for the purposes of:
- [ ] all designated States
- [ ] all designated States except the United States of America
- [ ] the United States of America only
- [ ] the States indicated in the Supplemental Box

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)*

This person is:
- [ ] applicant only
- [ ] applicant and inventor
- [ ] inventor only *(If this check-box is marked, do not fill in below.)*

State *(that is, country)* of nationality:

State *(that is, country)* of residence:

This person is applicant for the purposes of:
- [ ] all designated States
- [ ] all designated States except the United States of America
- [ ] the United States of America only
- [ ] the States indicated in the Supplemental Box

- [ ] Further applicants and/or (further) inventors are indicated on another continuation sheet.

Box No.V DESIGNATION OF STATES

The following designations are hereby made under Rule 4.9(a) *(mark the applicable check-boxes; at least one must be marked)*:

Regional Patent

☐ AP ARIPO Patent: GH Ghana, GM Gambia, KE Kenya, LS Lesotho, MW Malawi, SD Sudan, SL Sierra Leone, SZ Swaziland, TZ United Republic of Tanzania, UG Uganda, ZW Zimbabwe, and any other State which is a Contracting State of the Harare Protocol and of the PCT

☐ EA Eurasian Patent: AM Armenia, AZ Azerbaijan, BY Belarus, KG Kyrgyzstan, KZ Kazakhstan, MD Republic of Moldova, RU Russian Federation, TJ Tajikistan, TM Turkmenistan, and any other State which is a Contracting State of the Eurasian Patent Convention and of the PCT

☒ EP European Patent: AT Austria, BE Belgium, CH and LI Switzerland and Liechtenstein, CY Cyprus, DE Germany, DK Denmark, ES Spain, FI Finland, FR France, GB United Kingdom, GR Greece, IE Ireland, IT Italy, LU Luxembourg, MC Monaco, NL Netherlands, PT Portugal, SE Sweden, and any other State which is a Contracting State of the European Patent Convention and of the PCT

☐ OA OAPI Patent: BF Burkina Faso, BJ Benin, CF Central African Republic, CG Congo, CI Côte d'Ivoire, CM Cameroon, GA Gabon, GN Guinea, GW Guinea-Bissau, ML Mali, MR Mauritania, NE Niger, SN Senegal, TD Chad, TG Togo, and any other State which is a member State of OAPI and a Contracting State of the PCT *(if other kind of protection or treatment desired, specify on dotted line)* .....

National Patent *(if other kind of protection or treatment desired, specify on dotted line)*:

☐ AE United Arab Emirates
☐ AL Albania .....
☐ AM Armenia .....
☐ AT Austria .....
☐ AU Australia .....
☐ AZ Azerbaijan
☐ BA Bosnia and Herzegovina .....
☐ BB Barbados
☐ BG Bulgaria .....
☐ BR Brazil .....
☐ BY Belarus .....
☐ CA Canada
☐ CH and LI Switzerland and Liechtenstein
☒ CN China .....
☐ CR Costa Rica .....
☐ CU Cuba .....
☐ CZ Czech Republic .....
☐ DE Germany .....
☐ DK Denmark .....
☐ DM Dominica
☐ EE Estonia .....
☐ ES Spain .....
☐ FI Finland .....
☐ GB United Kingdom
☐ GD Grenada
☐ GE Georgia .....
☐ GH Ghana .....
☐ GM Gambia
☐ HR Croatia .....
☐ HU Hungary .....
☐ ID Indonesia
☐ IL Israel .....
☐ IN India .....
☐ IS Iceland
☒ JP Japan .....
☐ KE Kenya .....
☐ KG Kyrgyzstan .....
☐ KP Democratic People's Republic of Korea .....
☐ KR Republic of Korea .....
☐ KZ Kazakhstan .....
☐ LC Saint Lucia
☐ LK Sri Lanka
☐ LR Liberia
☐ LS Lesotho .....
☐ LT Lithuania
☐ LU Luxembourg
☐ LV Latvia
☐ MA Morocco .....
☐ MD Republic of Moldova .....
☐ MG Madagascar .....
☐ MK The former Yugoslav Republic of Macedonia .....
☐ MN Mongolia
☐ MW Malawi .....
☐ MX Mexico .....
☐ NO Norway
☐ NZ New Zealand .....
☐ PL Poland .....
☐ PT Portugal .....
☐ RO Romania
☐ RU Russian Federation .....
☐ SD Sudan
☐ SE Sweden
☐ SG Singapore
☐ SI Slovenia .....
☐ SK Slovakia .....
☐ SL Sierra Leone .....
☐ TJ Tajikistan .....
☐ TM Turkmenistan .....
☐ TR Turkey .....
☐ TT Trinidad and Tobago .....
☐ TZ United Republic of Tanzania
☐ UA Ukraine .....
☐ UG Uganda .....
☒ US United States of America .....
☐ UZ Uzbekistan .....
☐ VN Viet Nam .....
☐ YU Yugoslavia .....
☐ ZA South Africa .....
☐ ZW Zimbabwe .....

Check-boxes reserved for designating States which have become party to the PCT after issuance of this sheet:

☐ .....
☐ .....

Precautionary Designation Statement: In addition to the designations made above, the applicant also makes under Rule 4.9(b) all other designations which would be permitted under the PCT except any designation(s) indicated in the Supplemental Box as being excluded from the scope of this statement. The applicant declares that those additional designations are subject to confirmation and that any designation which is not confirmed before the expiration of 15 months from the priority date is to be regarded as withdrawn by the applicant at the expiration of that time limit. *(Confirmation (including fees) must reach the receiving Office within the 15-month time limit.)*

Box No. VI PRIORITY CLAIM ☐ Further priority claims are indicated in the Supplemental Box.

Filing date of earlier application *(day/month/year)*	Number of earlier application	Where earlier application is: national application: country	regional application:* regional Office	international application: receiving Office
item (1) 5 June 1999 (05. 06. 1999)	1999-20852	KR		
item (2) 5 June 1999 (05. 06. 1999)	1999-20854	KR		
item (3)				

☐ The receiving Office is requested to prepare and transmit to the International Bureau a certified copy of the earlier application(s) *(only if the earlier application was filed with the Office which for the purposes of the present international application is the receiving Office)* identified above as item(s): _____

* *Where the earlier application is an ARIPO application, it is mandatory to indicate in the Supplemental Box at least one country party to the Paris Convention for the Protection of Industrial Property for which that earlier application was filed (Rule 4.10(b)(ii)). See Supplemental Box.*

Box No. VII INTERNATIONAL SEARCHING AUTHORITY

Choice of International Searching Authority (ISA) *(if two or more International Searching Authorities are competent to carry out the international search, indicate the Authority chosen; the two-letter code may be used)* :

ISA / AT

Request to use results of earlier search; reference to that search *(if an earlier search has been carried out by or requested from the International Searching Authority):*

Date *(day/month/year)* Number Country *(or regional Office)*

Box No. VIII CHECK LIST; LANGUAGE OF FILING

This international application contains the following **number of sheets**:

request	:	4
description (excluding sequence listing part)	:	17
claims	:	9
abstract	:	1
drawings	:	6
sequence listing part of description	:	
Total number of sheets	:	37

This international application is **accompanied** by the item(s) marked below:

1. ☒ fee calculation sheet
2. ☒ separate signed power of attorney
3. ☐ copy of general power of attorney; reference number, if any:
4. ☐ statement explaining lack of signature
5. ☒ priority document(s) identified in Box No. VI as item(s):
6. ☐ translation of international application into (language):
7. ☐ separate indications concerning deposited microorganism or other biological material
8. ☐ nucleotide and/or amino acid sequence listing in computer readable form
9. ☐ other *(specify)*:

Figure of the drawings which should accompany the abstract: 1

Language of filing of the international application: English

Box No. IX SIGNATURE OF APPLICANT OR AGENT

Next to each signature, indicate the name of the person signing and the capacity in which the person signs (if such capacity is not obvious from reading the request).

JANG, Seong Ku (Seal)

For receiving Office use only

1. Date of actual receipt of the purported international application:
2. Drawings: ☐ received: ☐ not received:
3. Corrected date of actual receipt due to later but timely received papers or drawings completing the purported international application:
4. Date of timely receipt of the required corrections under PCT Article 11(2):
5. International Searching Authority (if two or more are competent): ISA /
6. ☐ Transmittal of search copy delayed until search fee is paid.

For International Bureau use only

Date of receipt of the record copy by the International Bureau: